PRELIMINARY RESEARCH PROPOSAL
SUBMITTED TO THE U.S. ARMY CORPS OF ENGINEERS UNDER THE ANADROMOUS FISH EVALUATION PROGRAM
2007 PROJECT YEAR

I. BASIC INFORMATION

A. TITLE OF PROJECT

Fish Approach and Survival by Route at Bonneville Dam in 2007

B. PROJECT LEADERS

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C. STUDY CODES

SPE-P-02-02:	Survival of Juvenile Salmonids through the Spillway at Bonneville Dam
SPE-P-02-1:	Second Powerhouse Corner Collection Efficiency Improvements at Bonneville Dam
SPE-P-06-02:	Comparative Performance of Acoustic-Tagged and PIT-Tagged Juvenile Salmonids This study will contribute additional acoustic detection sites for the comparative study.

D. ANTICIPATED DURATION

1 January 2007 through 31 December 2007

E. DATE OF SUBMISSION

August 7, 2006

II. PROJECT SUMMARY

A. GOALS

The long-term goal is to develop an unbiased method of estimating route-specific survival using acoustic telemetry by continually identifying and minimizing tag effects and by optimizing receiver deployments.

We have three goals for the proposed 2007 Bonneville Dam (BON) survival study:

1. We will estimate the percent of tagged yearling Chinook (YC) salmon and sub-yearling Chinook (SYC) salmon that pass through individual turbines, spill bays, sluiceway outlets from the B1 forebay, the B2 Corner Collector (B2CC), and the guided and unguided percentages for B2 turbines. Passage through B1 will be confirmed by temporally reasonable detections in the B1 tailrace. Guided and unguided fractions

of B2 turbine passage will be estimated from Passive Integrate Transponder (PIT) or acoustic detections in the bypass channel or on a B2 tailrace array, respectively. We will calculate passage metrics including Project FPE, FPE by powerhouse, spill efficiency, B1 sluiceway efficiency, B2CC efficiency, combined sluiceway efficiency, B2 FGE, and the effectiveness of the spillway and sluiceways.

2. We will estimate survival of tagged fish in spring and summer for the entire Project and for all major passage routes relative to survival of control fish released downstream of the project. The relative survival of tagged fish at spill bays with two different types of deflectors is of particular interest, and overall spillway survival will have a one-half, 95% confidence interval ≤ 4%.
3. We will evaluate the efficiency of a 400-ft long floating trash boom for guiding acoustically tagged Chinook salmon to the B2 Corner Collector (B2CC). Efficiency can be estimated as the percent of fish guided by the boom based upon 3-D tracking and upon the efficiency of the B2CC relative to its efficiency in 2004 and 2005 before the boom was deployed.

B. OBJECTIVES

1. Surgically implant about 4,500 YC salmon and 4,200 SYC salmon with PIT and Juvenile Salmonid Acoustic Transmitters (JSATs) acoustic tags at the John Day Smolt Monitoring Facility (SMF) and release them in the tailwater below The Dalles Dam (TDA) in 20 batches of about 225 per day in spring and 20 batches of 210 per day in summer. Based upon historical spill-efficiency data and detection probabilities on acoustic survival arrays in 2006, these releases should provide one-half 95% confidence intervals of ≤ 4% for spillway survival.
2. Conduct a tag-life study of 200 randomly sampled JSATs tags that will be used in all survival studies in 2007 to provide tag-life corrections for survival estimates, if necessary.
3. Deploy and maintain a four-node detection array upstream of Boat Rock, which is immediately upstream of entrances to B1, spillway, and B2 forebays. This array will allow us to identify surviving Chinook salmon from releases below TDA (Objective 1), and also to regroup surviving individuals out of 3,500 yearlings and 7,000 sub-yearlings scheduled for release below Lower Granite Dam on the Snake River under a proposed 2007 Tag-effects Study.
4. Deploy and maintain four or five 3-D tracking nodes in each of three forebay areas of BON to track all JSATS tagged fish into their ultimate route of passage. These nodes also will collectively constitute a secondary array for the Boat Rock array so that survival can be estimated for fish released on the Snake River and from below TDA to the Bonneville forebay.
5. Evaluate the guidance efficiency and relative performance of a 400-ft long trash boom in the B2 forebay. Three dimensional tracking of tagged fish in the B2 forebay will provide definitive metrics for evaluating the efficiency of the boom for guiding fish to the B2CC. Efficiency metrics could include the number of fish moving along the boom (upstream or downstream of it) divided by the number detected moving across and along the boom or divided by the total number detected in the B2 forebay. These guidance metrics can be estimated for day and night arrivals or all arrivals each season. The fish-passage efficiency and effectiveness of the B2CC relative to B2 and to the entire Project in 2007 can be compared with B2CC estimates in 2004 and 2005 before the trash boom was deployed to determine whether the boom improved B2CC performance.
6. Calculate fish passage metrics including Project FPE, FPE by powerhouse, spill efficiency, B1 sluiceway efficiency, B2CC efficiency, combined sluiceway efficiency, B2 FGE, and the effectiveness of the spillway and sluiceways. We will compare these estimates with previous estimates by radio telemetry and hydroacoustics and thoroughly discuss similarities and differences.
7. Deploy and maintain detection arrays in the B1 and B2 tailraces to verify passage of tagged fish through B1 and through B2 turbines (unguided passage). A hydrophone will be deployed in the B2 bypass channel to detect acoustically tagged fish guided by submerged traveling screens (STSs) at B2. We also will query the PIT Tag Information System (PTAGIS) to confirm passage of tagged fish through the B2CC and the B2 Juvenile Bypass System (JBS).

8. Deploy and maintain a primary tailwater survival array between Skamania and Sand Islands (12 miles downstream of BON, a secondary array at Reed Island (19 miles downstream), and a tertiary array at Lady Island (25 miles downstream). Detections on these arrays will complete capture histories for route-specific survival estimates using single- and paired-release survival models.
9. Process data using TagViz software to match codes detected at least three times in chronological order with released codes, develop time-of-detection histories for all arrays, and calculate detection probabilities for the primary and secondary forebay arrays and primary, secondary, and tertiary tailwater arrays by season and release treatment.
10. Estimate distribution statistics associated with the time required for forebay passage and for Project passage and tailrace egress. Forebay passage time will be calculated by subtracting the time of last detection on the secondary forebay array from the time of last detection on the primary forebay array just upstream of Boat Rock. Project passage and tailrace egress time will be calculated by subtracting the time of detection on B1 or B2 tailrace arrays from the time of last detection on the corresponding B1 or B2 secondary forebay array.
11. Estimate survival by route of passage based upon detection histories of treatment and control fish at the primary, secondary, and tertiary tailwater arrays, using paired-release survival models. Routes will be pooled by type (e.g., spill bays with 7-ft- and 14-ft-elevation deflectors, B1 turbines, or B2 turbines) to improve sample sizes and increase precision. All survival estimates will be accompanied by an estimate of the one-half 95% confidence interval.
12. Estimate reach or Dam survival using single release models for tagged fish from Lower Granite Dam to the Bonneville Forebay, from The Dalles Tailrace to the Bonneville Forebay, from the Bonneville Forebay to the primary and secondary arrays between Skamania Island and Reed Island, and from the Bonneville tailrace to the same primary and secondary arrays.
13. Compare all passage and survival results with previous estimates based upon radio telemetry methods.

C. METHODOLOGY

For 20 days during the central 80% of the spring migration season, we will surgically implant about 225 YC salmon per day (4,500 total) with PIT and JSATs acoustic tags at the John Day Smolt Monitoring Facility (SMF), hold them for about 24 h, and release them in uniform numbers along a transect adjacent to The Dalles Marina. The same procedure will be used in summer, except that about 210 SYC salmon will be tagged and released daily for 20 days (ca. 4,200 fish). Under the Estuary Survival Study, about 2,000 YC salmon in spring and 3,000 SYC salmon in summer will be released in the tailwater about 2 miles below BON, and these fish will be used as control releases in paired-release survival models developed for this study. Any fish that dies during the pre-release holding period will be recorded as dead and released to determine whether dead fish travel far enough downstream to be detected on tailwater survival arrays 12-25 miles below BON.

In addition to the 4,500 yearlings and 4,200 sub-yearlings released below TDA, this study also will detect and take advantage of surviving fish out of 3,500 YC and 7,000 SYC salmon scheduled for tagging and release below Lower Granite Dam in 2007, under a Tag-effects Study. Based on historical spill-efficiency data and on detection and survival estimates by acoustic telemetry in spring and summer 2006, 4,500 yearlings and 4,200 sub-yearlings from TDA alone should provide one-half 95% confidence intervals of < 4% for spillway survival at BON. Given the planned addition of one additional autonomous node to all three tailwater survival arrays, detectability and precision should be better in 2007 than it was in 2006.

We will conduct a tag-life study of 200 randomly sampled tags that will be used in all JSATs survival studies in 2007. About 100 tags that transmit once every 10 s and 100 tags that transmit once every 5 s will be randomly selected from all available tags, activated, and implanted in hatchery rainbow trout that will be held until all tags are dead. A mobile node will be used to listen for tags daily, and tag-life histories will be reported and used to adjust detection and survival estimates, if necessary.

We will deploy two arrays upstream of BON, a primary array for detecting fish making there way to the Project from upstream, and the secondary for tracking fish in three dimensions within about 300 ft of each powerhouse and the spillway to assign route of passage. The presence of these two arrays will allow us to calculate the survival of fish to the entrance of the BON forebay from their release locations upstream. The primary forebay array will detect individual fish and their time of arrival at the Project. Forebay residence time will be calculated as the time of the last recorded detection by 3-D tracking nodes (i.e., the assigned time of dam passage) minus the time of the last recorded detection on the primary forebay array. Therefore, accurate setting of autonomous node clocks will be very important. A GPS-synchronized clock will be used to set clocks on autonomous nodes, obtain release times, and determine clock drift in every autonomous node based upon the difference in node time upon recovery from GPS time.

Three dimensional tracking of tagged fish will be done from four or five 3-D tracking nodes deployed on the bottom of each of the three forebay areas of BON. Tracking of fish within about 300 ft of the powerhouse is crucial for assigning route of passage for fish approaching B1 and the B2CC, although two-dimensional tracking probably will be sufficient for tracking into spill bays and B2 turbines. Error in estimates of target position estimation should be < 1 m, and we should be able to track fish into sluiceways and up to turbine trash racks and spill gates, so ambiguous tracks should be rare. However, the frequency of tag transmission and fish speed will affect the spacing between successive position estimates. The 3-D tracking nodes also will collectively constitute a secondary array for the Boat Rock array upstream, so that survival to the BON Project can be estimated for fish from LGR and fish from TDA.

We will thoroughly evaluate the guidance efficiency and relative performance of the 400-ft long trash boom in the B2 forebay. Three dimensional tracking of tagged fish in the B2 forebay will provide definitive metrics for evaluating the efficiency of the 400-ft long trash boom for guiding fish to the B2CC. Efficiency metrics could include the number of fish moving along the boom (upstream or downstream of it) divided by the number detected moving across and along the boom or divided by the total number detected in the B2 forebay. The fish-passage efficiency and effectiveness of the B2CC relative to B2 and to the entire Project in 2007 can be compared with B2CC estimates in 2004 and 2005 before the trash boom was deployed to determine whether the boom improved B2CC performance.

Based upon route-specific passage estimates from 3D tracking, we will calculate fish-passage metrics including Project FPE, FPE by powerhouse, spill efficiency, B1 sluiceway efficiency, B2CC efficiency, combined sluiceway efficiency, B2 FGE, and the effectiveness of the spillway and sluiceways. We will compare these estimates with previous estimates by radio telemetry and hydroacoustics and thoroughly discuss similarities and differences.

We will deploy a 4-node egress array about 1,000 ft downstream of each powerhouse to confirm passage of tagged fish through B1 and B2 turbines, and to estimate the combined time required for passage and tailrace egress. A hydrophone will be deployed in the B2 bypass channel to detect tagged fish guided by submerged traveling screens (STSs) at B2, and we will query PTAGIS to confirm passage of tagged fish through the B2CC and the B2 JBS. The B2 tailrace array should provide good confirmation of passage unguided through B2 turbines provided detections occur within minutes after fish are tracked into a turbine intake upstream.

The heart of the survival study is the deployment and maintenance of a primary array located about 12 miles below the dam, a secondary array 19 miles downstream, and a tertiary array 25 miles downstream. These arrays will be used to detect surviving Chinook salmon assigned a route of passage through BON and to detect surviving control fish released in the Bonneville tailwater by the Estuary Survival Study. In 2007, we will deploy seven nodes in the primary array, five in the secondary, and five in the tertiary, one more than was deployed at each array in 2006. Therefore the number of fish proposed for release in 2007, based upon modeling of required sample-sizes using 2006 detection and survival statistics, should be more than adequate to deliver desired precision. The use of three detection arrays will allow us to make two estimates of detection probabilities and survival and to test independence assumptions of the single release model using Burnham Tests 2 and 3 (Burnham et al. 1987).

All autonomous nodes will be checked weekly and replaced if problems are found, but otherwise they will be sequentially serviced every 30 days to install fresh batteries, synchronize clocks, and download data. The time required to service and redeploy an autonomous node is about 30 minutes. Downloaded data will be stored on two sets of media to provide backup. Data from the 3-D tracking nodes in the forebay areas will be downloaded daily and backed up off site.

We will process detection data using TagViz software to match codes detected at least three times in chronological order with released codes, develop detection histories for all tags released below LGR, below TDA, and below BON at each of the detection arrays described above. The software is useful for quickly eliminating improbable false detections based upon detection location and time relative to release times and prior detection locations and times. The TagViz data base will contain tag activation and detection histories for all ongoing JSATs studies in 2007, so information about releases and detections for a specific study or all related studies will be readily accessible.

We will estimate forebay egress time by subtracting the time of last detection on 3-D tracking nodes from the time of detection on the Boat Rock array above the project, and B1 and B2 passage and egress times by subtracting the time of detection on B1 and B2 tailrace arrays from the time of last detection at a passage route on 3-D tracking nodes in forebay areas immediately upstream.

We will estimate survival by route of passage based upon detection histories of tagged fish at the primary, secondary, and tertiary arrays using paired-release models. The precision of route-specific estimates will depend upon the number of fish passing by each route, so it makes sense to pool estimates by type of route when numbers passing through individual routes are low. We will estimate survival separately for fish released below TDA and fish released below Lower Granite Dam, and if estimates do not differ significantly, we also will provide estimates based on pooled numbers to improve precision of survival estimates. We expect that there will be enough fish to make estimates for the B1 sluiceway, the B2CC, all surface routes combined, B1 turbines, spill bays with 7-ft- and 14-ft-elevation deflectors, the B2 JBS, and B2 turbines. We are unlikely to have enough fish to make useful estimates for individual sluiceway outlets from the B1 forebay, individual turbines or subgroups of turbines at either powerhouse, or individual spill bays. All survival estimates will be accompanied by estimates of precision (one half 95% confidence intervals). We also should be able to look at B1, spillway, and B2 survival by day and night in spring, and by spill-discharge level, which will vary between day and night in summer. We anticipate that spill will be constant 24 hours per day in spring, but will be higher at night than during the day in summer. We will compare all survival estimates to estimates made in previous years with radio telemetry.

After data have been acquired, we will use custom-designed single- and paired-release models (SRM and PRM) to estimate survival for the following reaches:

1. Lower Granite tailwater to the primary forebay array immediately upstream of Boat Rock (SRM)
2. The Dalles tailwater to the primary forebay array (SRM). While estimating survival for this reach was not a specific goal of the study, the configuration of an entrance array to the Project and 3-D tracking arrays will make this estimate possible.
3. The Bonneville forebay primary array to the tailwater primary and secondary arrays (SRM).

4. Bonneville forebay route or types of route to the tailwater primary and secondary arrays (PRM). This estimate will use the ratio of survival estimates of treatment fish passing through a type of route to the survival of control fish released in the tailwater under the Estuary Survival Study.

D. RELEVANCE TO THE BIOLOGICAL OPINION

This study addresses two Biological Opinion Measures under Hydro Sub Strategies 1.4, including # 82 on spill survival and # 66 on the B2 Corner Collector. It specifically addresses important questions raised in two 2007 one pagers (Study Code SPE-P-02-02 on spillway survival at BON and SPE-P-02-1 on evaluating B2CC efficiency improvements). The proposed study also is related to Reasonable and Prudent Alternative (RPA) 195 of the NMFS 2000 FCRPS BiOp, which required the Corps to "evaluate survival of fish passing through the FCRPS below BON. The river reach from BON down to Reed Island is the gateway to the estuary. The 2000 BiOp RPA 68 mentions continued spill and fish passage survival studies, and other RPAs relate to juvenile salmonid survival at FCRPS Dams (58, 82, 83, 88, 89, 90, 98, 105, 134, and 141). Continued development of survival methods is critical for evaluating any structural or operational changes.

III. PROJECT DESCRIPTION

A. BACKGROUND

The Corps of Engineers is committed to increasing survival rates for fish passing its projects on the Columbia River, and survival is one of the primary measures of success of management improvements at hydropower projects. The earliest survival studies at BON were conducted between 1939 and 1945, summarized by Holmes (1952), and estimated survival ranging from 85-89 percent. The next series of investigations that assessed the effects of turbine passage on smolt survival (as part of a much broader research effort) commenced in 1987 and continued in most years through 1992 (Dawley et al. 1988 and 1989; Ledgerwood et al. 1990, 1991, and 1994). Giorgi et al. (2005) pointed out that the scope of those studies was broad and involved a variety of treatments and reference (control) releases that varied through the years. Short-term survival was estimated using branded fish recovered with seines near Jones Beach. Long-term survival was to be based on recoveries of CWT at hatcheries and within the fishery. Unfortunately, adult return rates were so low that meaningful comparisons among treatment and reference groups was impractical (Gilbreath et al. 1992). Other indirect survival studies at Bonneville include Counihan et al. (2002b), Counihan et al. (2003), and Counihan et al. (2005a and b). Indirect survival studies have been conducted at the spillway (Normandeau et al. 1996, 2003), B1 turbines (Normandeau et al. 2000), and the B2CC (Normandeau et al. 2001).

Acoustic telemetry survival studies have become more common in recent years because of advantages such as functionality in fresh and salt water, no external antenna, detection throughout the water column, and the ability to track in two and even three dimensions. The Portland District of the Corps of Engineers is pursuing a transition from radio to acoustic telemetry for use in estimating project and dam passage behavior and survival. Acoustic detection probabilities for the primary and secondary arrays below BON in spring 2006 were 71% and 69% respectively. These estimates are acceptable, but outstanding spring detection probabilities from 2006 acoustic telemetry studies at John Day Dam (Primary = 99%; Joint primary and secondary: $S{\cdot}P$ = 0.92) and TDA (Primary = 94%; $S{\cdot}P$ = 0.81%) suggest that much better detection probabilities are possible.

A.1. PROBLEM DESCRIPTION

Additional survival estimates for several passage routes through Bonneville Dam are needed to provide information to help managers make decisions regarding optimal design or operations for the B1 sluiceway, the spillway, and the B2CC.

Two types of spillway deflectors have been studied in direct survival studies using balloon tags (Normandeau et al. 1996, 2001, and 2003) and indirect survival studies using radio telemetry (Counihan et al. 2005a and 2005b). In both cases, trends were apparent although usually not significant, and further evaluations are needed to identify effects and confirm results. New spillway flow deflectors were installed and new spill patterns were implemented at BON in 2002. Effects of the new deflector types at elevation 7 ft MSL were compared with effects of old deflectors at elevation 14 ft in a balloon-tag study to measure the direct survival under a high and low tailwater. The 2002 data suggested that when tailwater surface elevations are low, injury increased and survival decreased. Survival for elevation 14-ft deflectors were compared with survival of deflectors at elevation 7 ft, but estimates of precision were low (Normandeau et al. 2003). Radio-telemetry survival studies conducted in 2004 and 2005 showed a trend of decreasing survival for decreasing spill volumes, and bays equipped with the higher (14 ft) flow deflectors had lower survival than bays with the lower (7 ft) deflectors. Most results were not statistically significant, but trends had some consistency. One operational explanation for the lower survival is the new spill pattern, which uses smaller gate openings and more spill bays for the 75,000 cfs day spill. In 2006, a total survival evaluation that looked at 100,000 cfs spill for 24-hours per day in the spring, and a modified 75,000 cfs spill with larger gate openings was conducted in summer, but results are not yet available. There are a number of factors governing spill at Bonneville, including TDG limitations and effects of spill on adult passage. The former may preclude the ability to spill 100,000 cfs all of the time in spring. Therefore, a better understanding of the spillway mortality mechanism is needed so that decisions can be made regarding structural versus operational changes to improve survival.

Lower B2CC passage efficiency estimates for juvenile Chinook salmon than for steelhead and the high survival of all fish passing through the B2CC highlight the need to identify structural or operational alternatives that will increase the efficiency of the B2CC for all salmonids. The installation and evaluation of a 400-foot-long trash boom for guiding fish was proposed for 2007. A forebay trash boom at Lower Granite Dam was shown to effectively guide acoustic-tagged juvenile salmonids. The proposed Bonneville guidance system would be an off the shelf floating trash boom approximately 400 ft long. Survival studies in 2004 and 2005 indicated that the second powerhouse corner collector (B2CC) provided the highest survival of all passage routes for YC and SYC salmon, and juvenile steelhead (Counihan et al. 2005a and b). However, passage efficiency is less than desired, especially for YC and SYC salmon. The B2CC passage efficiencies for radio-tagged juvenile steelhead were 49 and 35% of total project passage in 2004 and 2005 (Reagan et al. 2005 and 2006), and this was much higher than efficiencies for YC salmon (22% in 2004; 16% in 2005) and for SYC salmon (22% in 2004 – Evans et al. 2005; 22% in 2005 – Farley et al. 2006).

The redesign of the B1 sluiceway is nearly about 80% complete, but provision of additional efficiency and possible survival estimates in 2007 under newly proposed operations with fully opened outlets above all Unit 1 intakes would be timely and useful. We began planning the 2007 study by focusing on the spillway and a B2 forebay guidance device, but we quickly realized that adding a four 3-D tracking receivers to B1 could replace a simple forebay detection array originally planned and would provide route-specific information by taking advantage of the many acoustic tags that will be in the river in spring and summer 2007.

A.2. SITE DESCRIPTION

The proposed study site includes most of the Bonneville Pool from The Dalles Marina down to Lady Island (Figure 1).

Figure 1. Map showing the primary study area for the proposed 2007 study. Juvenile Chinook salmon will be released evenly across the river adjacent to The Dalles Marina (treatment fish); the primary forebay detection array is just upstream of Boat Rock at the entrance to the three forebays of Bonneville Dam; fish also will be detected and tracked to a specific passage route at B1, the spillway, and B2 on a secondary forebay array; control fish will be released below Bonneville Dam and may be detected on the primary, secondary, and tertiary tailwater arrays at statute river mile (RM) 133.6, 127.0, and 120.4, respectively.

B. OBJECTIVES

1. Surgically implant about 4,500 YC salmon and 4,200 SYC salmon with PIT and JSATs acoustic tags at the John Day Smolt Monitoring Facility (SMF) and release them in the tailwater below TDA in 20 batches of about 225 per day in spring and 20 batches of 210 per day in summer. Based upon historical spill-efficiency data and detection probabilities on acoustic survival arrays in 2006, these releases should provide one-half 95% confidence intervals of ≤ 4% for spillway survival.
2. Conduct a tag-life study of 200 randomly sampled JSATs tags that will be used in all survival studies in 2007 to provide tag-life corrections for survival estimates, if necessary.
3. Deploy and maintain a four-node detection array upstream of Boat Rock, which is immediately upstream of entrances to B1, spillway, and B2 forebays. This array will allow us to identify surviving Chinook salmon from releases below TDA (Objective 1), and also to regroup surviving individuals out of 3,500 yearlings and 7,000 sub-yearlings scheduled for release below Lower Granite Dam on the Snake River under a proposed 2007 Tag-effects Study.
4. Deploy and maintain four or five 3-D tracking nodes in each of three forebay areas of BON to track all JSATS tagged fish into their ultimate route of passage. These nodes also will collectively constitute a secondary array for the Boat Rock array so that survival can be estimated for fish released on the Snake River and from below TDA to the Bonneville forebay.
5. Evaluate the guidance efficiency and relative performance of a 400-ft long trash boom in the B2 forebay. Three dimensional tracking of tagged fish in the B2 forebay will provide definitive metrics for evaluating the efficiency of the boom for guiding fish to the B2CC. Efficiency metrics could include the number of fish moving along the boom (upstream or downstream of it) divided by the number detected moving across and along the boom or divided by the total number detected in the B2 forebay. These guidance metrics can be estimated for day and night arrivals or all arrivals each season. The fish-passage efficiency and effectiveness of the B2CC relative to B2 and to the entire Project in 2007 can be compared with B2CC estimates in 2004 and 2005 before the trash boom was deployed to determine whether the boom improved B2CC performance.

6. Calculate fish passage metrics including Project FPE, FPE by powerhouse, spill efficiency, B1 sluiceway efficiency, B2CC efficiency, combined sluiceway efficiency, B2 FGE, and the effectiveness of the spillway and sluiceways. We will compare these estimates with previous estimates by radio telemetry and hydroacoustics and thoroughly discuss similarities and differences.
7. Deploy and maintain detection arrays in the B1 and B2 tailraces to verify passage of tagged fish through B1 and through B2 turbines (unguided passage). A hydrophone will be deployed in the B2 bypass channel to detect acoustically tagged fish guided by submerged traveling screens (STSs) at B2. We also will query the PIT Tag Information System (PTAGIS) to confirm passage of tagged fish through the B2CC and the B2 Juvenile Bypass System (JBS).
8. Deploy and maintain a primary tailwater survival array between Skamania and Sand Islands (12 miles downstream of BON, a secondary array at Reed Island (19 miles downstream), and a tertiary array at Lady Island (25 miles downstream). Detections on these arrays will complete capture histories for route-specific survival estimates using single- and paired-release survival models.
9. Process data using TagViz software to match codes detected at least three times in chronological order with released codes, develop time-of-detection histories for all arrays, and calculate detection probabilities for the primary and secondary forebay arrays and primary, secondary, and tertiary tailwater arrays by season and release treatment.
10. Estimate distribution statistics associated with the time required for forebay passage and for Project passage and tailrace egress. Forebay passage time will be calculated by subtracting the time of last detection on the secondary forebay array from the time of last detection on the primary forebay array just upstream of Boat Rock. Project passage and tailrace egress time will be calculated by subtracting the time of detection on B1 or B2 tailrace arrays from the time of last detection on the corresponding B1 or B2 secondary forebay array.
11. Estimate survival by route of passage based upon detection histories of treatment and control fish at the primary, secondary, and tertiary tailwater arrays, using paired-release survival models. Routes will be pooled by type (e.g., spill bays with 7-ft- and 14-ft-elevation deflectors, B1 turbines, or B2 turbines) to improve sample sizes and increase precision. All survival estimates will be accompanied by an estimate of the one-half 95% confidence interval.
12. Estimate reach or Dam survival using single release models for tagged fish from Lower Granite Dam to the Bonneville Forebay, from The Dalles Tailrace to the Bonneville Forebay, from the Bonneville Forebay to the primary and secondary arrays between Skamania Island and Reed Island, and from the Bonneville tailrace to the same primary and secondary arrays.
13. Compare all passage and survival results with previous estimates based upon radio telemetry methods.

C.1. METHODOLOGY

Peven et al. (2005) provided a useful resource for developing methods in this proposal. Sample sizes required to provide one-half 95% confidence limits of ≤ 4% of survival estimates at the Bonneville spillway were estimated in a two-step process. First, we used SampleSize Version 1.3 software (after Lady et al. 2003) and preliminary detection statistics from the 2006 acoustic telemetry study to estimate the number of treatment fish that would need to be released to obtain one-half 95% confidence limits of ≤ 4% (Figures 2 and 3). Second, we divided those estimated numbers by the lowest spill-passage efficiency estimates recorded in radio-telemetry studies between 2000 through 2005 (Table 1) and then rounded the numbers up to the next highest 100 fish for estimated sample sizes for this proposal (Table 2).

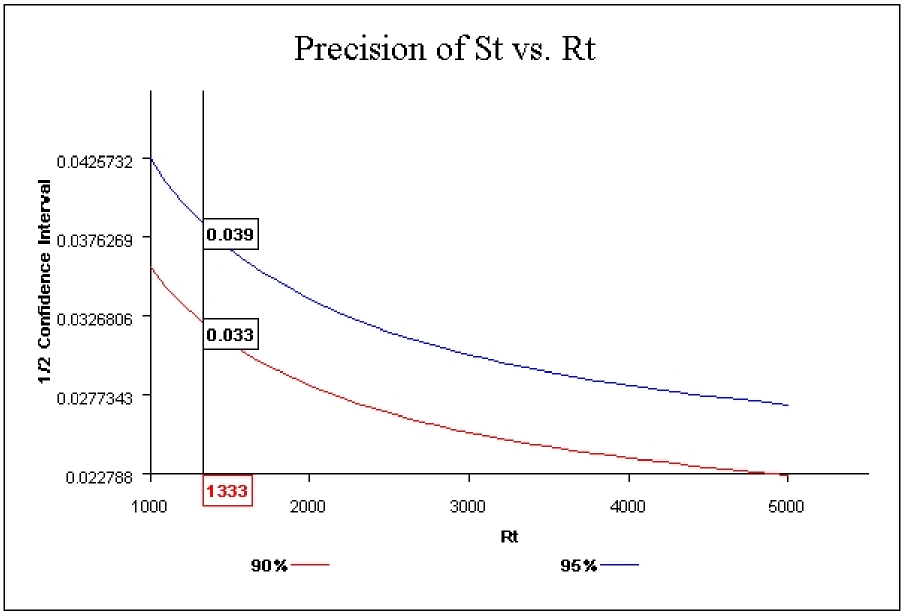

Figure 2. Number of Yearling Chinook Salmon Required in Spring to Provide One-half 95% Confidence Intervals of ≤ 4% on the Survival of Treatment Fish (St) as a Function of Release Sample Size (Rt). Input parameters included 2,000 control fish, 1,000 to 5,000 treatment fish, mean treatment fish survival (0.91), mean control fish survival (0.95), mean primary array detection probability (0.71), mean joint array probability (S·P = 0.64).

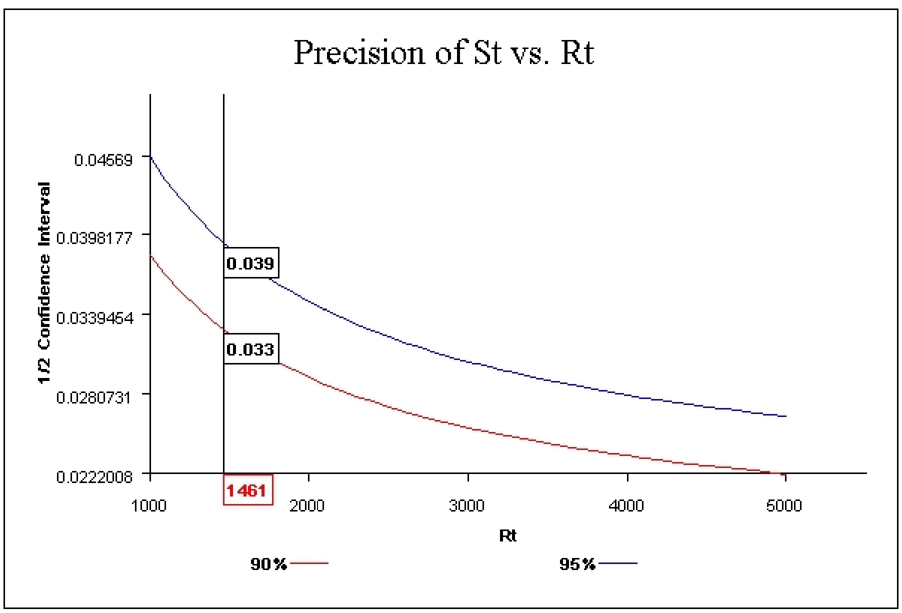

Figure 3. Number of Sub-yearling Chinook Salmon Required in Summer to Provide One-half 95% Confidence Intervals of ≤ 4% on the Survival of Treatment Fish (St) as a Function of Release Sample Size (Rt). Input parameters included 3,000 control fish, 1,000 to 5,000 treatment fish, mean treatment fish survival (0.85), mean control fish survival (0.95), mean primary array detection probability (0.69), mean joint array probability (S·P = 0.59).

Table 1. Chinook Salmon Spill-Passage Efficiency[1]

Year	Spring	Summer
2000	44	65
2001	30[2]	NA
2002	57	58
2004	33	35
2005	39	49
Mean	43	47

[1] Evans et al. 2001a, b, c, d, 2002, 2003a and b, 2006; Adams et al. 2006; Farley et al. 2006; Reagan et al. 2005 and 2006
2 During 37% spill only

Table 2. Release Sample Size Required for ≤ 4% One-half 95% Confidence Limits for the Spillway.

Sample Size	Spring	Summer	Source
Required at Spillway	1,333	1,461	Sample Size Estimates
Required Release	1,333 ÷ 0.30 = 4,443	1,461 ÷ 0.35 = 4,174	R_t / Spill Efficiency

For 20 days during the central 80% of the spring migration season, we will surgically implant about 225 YC salmon per day with PIT and JSATs acoustic tags at the John Day Smolt Monitoring Facility (SMF), hold them for about 24 h, and release them uniformly along a river transect adjacent to The Dalles Marina (Figure 4). The spring total will be about 4,500 fish. The same procedure will be used in summer, except that about 210 SYC salmon will be tagged and released daily for 20 days (ca. 4,200 fish). Under the Estuary Survival Study, about 2,000 YC salmon in spring and 3,000 SYC salmon in summer will be released in the tailwater about 2 miles below BON, and these fish will be used as control releases in paired-release survival models developed for this study. Any fish that dies during the pre-release holding period will be recorded as dead and released to determine whether dead fish travel far enough downstream to be detected on tailwater survival arrays 12-25 miles below BON. Micro-acoustic transmitters will weigh no more than 0.5 g in air and will transmit 417 kHz sound once every 5 seconds for about 30 days. Fish will be surgically implanted using a procedure similar to that described by Adams et al. (1998), excluding details about the external antenna. The acoustic tag will be no larger than 5.5 mm wide x 4.8 mm thick x 19 mm long. Fish will be individually anesthetized with tricaine methanesulfonate (MS-222). While immobile, fish will be weighed and measured, and the PIT tag and acoustic tag codes associated with the fish will be recorded. The fish will be placed dorsal surface down on a foam operating table, and a continuous supply of anesthetic water will be delivered during surgery by a tube inserted into the mouth. A 10-mm incision will be made approximately 2 mm to the left of the mid-ventral line just anterior to the pelvic fin girdle. A PIT tag will first be inserted through the incision into the abdominal cavity, followed by a functioning acoustic transmitter. The incision will be closed by two interrupted sutures, and the fish will be placed in a bucket of fresh water with supplemental oxygen for observation during recovery.

Fish will be obtained from the JDA Juvenile Fish Facility. All necessary permits will be obtained by PNNL and NOAA Fisheries. All tagged fish will be held for 24 h to evaluate short-term tagging effects prior to release. Any fish that dies during the pre-release holding period will be recorded as dead and released to determine whether they travel far enough downstream to be detected by the primary forebay array at BON.

If tagging mortality is as low as it was in 2006 (< 1%), some fish will have to be purposely sacrificed so that a total of 20 dead tagged fish can be released each season. Each day, fish will be released uniformly across the river adjacent to The Dalles Marina about 2 miles below TDA. Notes on the condition of tagged fish during the 24-h holding period or of fish subsequently PIT detected will become part of the study record.

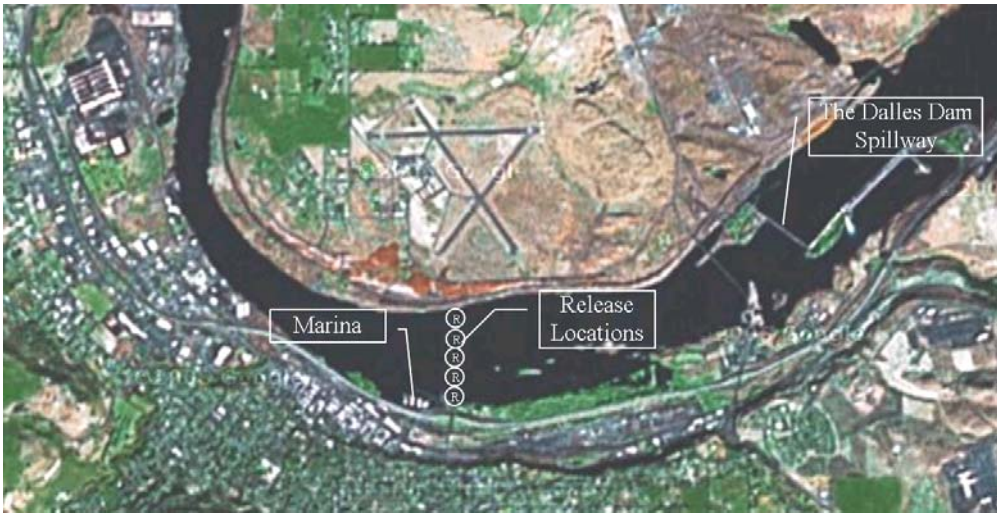

Figure 4. Photograph of the Release Location and Lateral Distribution for 20 Daily Releases of Yearling Chinook Salmon in Spring (4,500 total) and 20 Daily Releases of Sub-yearling Chinook Salmon in Summer (4,200 total).

In addition to the 4,500 YC and 4,200 SYC salmon released below TDA, this study also will detect and take advantage of surviving fish out of 3,500 YC and 7,000 SYC salmon scheduled for tagging and release below Lower Granite Dam in 2007, under a Tag-effects Study. Based on historical spill-efficiency data and on detection and survival estimates by acoustic telemetry in spring and summer 2006, 4,000 yearlings and 4,900 sub-yearlings from TDA alone should provide one-half 95% confidence intervals of ≤ 4% for spillway survival at BON. Given the planned addition of one additional autonomous node to all three downstream survival arrays, detectability and precision should be better in 2007 than it was in 2006.

We will conduct a tag-life study of 200 randomly sampled JSATs tags that will be used in all survival studies in 2006. About 100 tags that transmit once every 10 s and 100 tags that transmit once every 5 s will be randomly selected from all available tags, activated, and implanted in hatchery rainbow trout that will be held until all tags are dead. A mobile node will be used to listen for tags daily, and tag-life histories will be reported and used to adjust detection and survival estimates, if necessary.

The maximum range of detection based upon the receiving sensitivity of JSATs autonomous nodes and the source levels of acoustic micro-tags ranges from about 300 to 400 ft depending upon ambient acoustic conditions in the river. We will space autonomous detection hydrophones and 3-D tracking nodes, each with four hydrophones within 250 ft from shore and ≤ 500 from one another to ensure complete coverage of the intended sample volume at a cross section and provide some redundancy against the loss of a node inside the near-shore nodes. All arrays will be spaced far enough apart to prevent simultaneous detection of tagged fish by two arrays. The use of three tailwater survival arrays will allow us to make two estimates of detection probabilities and survival and to test independence assumptions of the single release model. The model assumes that upstream detection history has no effect on downstream detection history or survival, and this can be tested using Burnham Tests 2 and 3.

We will deploy two arrays upstream of BON, a primary array for detecting fish making there way to the Project from upstream, and the secondary for tracking fish in three dimensions within about 300 ft of each powerhouse and the spillway to assign route of passage (Figure 5). The presence of these two arrays will allow us to calculate the survival of fish to the entrance of BON forebay from their release locations upstream. The primary forebay array will detect individual fish and their time of arrival at the Project, which will start the clock for determining forebay residence time, which is the time a fish was last detected by 3-D tracking nodes minus the time a fish was last detected on the primary forebay array. Therefore, accurate setting of autonomous node clocks will be very important. A GPS-synchronized clock will be used to set clocks on autonomous nodes, obtain release times, and determine clock drift in every autonomous node based upon the difference in node time upon recovery from GPS time.

Three dimensional tracking of tagged fish will be done from four or five 3-D tracking nodes deployed on the bottom of each of the three forebay areas of BON (Figure 5). Tracking of fish within about 300 ft of the powerhouse is crucial for assigning route of passage for fish approaching B1 and the B2CC, although two-dimensional tracking probably would be sufficient for tracking into spill bays and B2 turbines. A fish track is a time series of position estimates converted to real-world coordinates. The track of every tagged fish will be isolated and animated relative to images of the three dam structures from existing computational fluid dynamics (CFD) models so that Biologists can accurately assign route of passage based upon track heading and the last detected position. We will not assign a specific route for fish last detected > 3 m upstream of a route, but a general route such as "turbine" or spillway may be assigned if the track is imprecise but the likely fate is not ambiguous. Error in estimates of target position estimation should be < 1 m, and we should be able to track fish into sluiceways and up to turbine trash racks and spill gates, so ambiguous tracks should be rare. However, the frequency of tag transmission and fish speed will affect the spacing between successive positions. For example, a smolt with a 5-second tag moving 2 ft / s would have about 10 ft between successive detections, whereas the same smolt with a 10-second tag would have about 20 ft between successive positions. Therefore, Lower Granite tags, which will ping once every 10 seconds for 60 days will produce sparser tracks than TDA fish with 5 second tags lasting 30 days. The 3-D tracking nodes also will collectively constitute a secondary array for the primary forebay array above Boat Rock, so that survival to the BON Project can be estimated for fish from LGR and TDA.

We will thoroughly evaluate the guidance efficiency and relative performance of the 400-ft long trash boom in the B2 forebay. Three dimensional tracking of tagged fish in the B2 forebay will provide definitive metrics for evaluating the guidance efficiency of the 400-ft long trash boom for guiding fish to the B2CC. Efficiency metrics could include the number of fish moving along the boom (upstream or downstream of it) divided by the number detected moving across and along the boom or divided by the total number detected in the B2 forebay. These guidance metrics can be estimated for day and night arrivals or all arrivals each season. The fish-passage efficiency and effectiveness of the B2CC relative to B2 and to the entire Project in 2007 can be compared with estimates in 2004 and 2005 before the trash boom was deployed to determine whether the boom improved B2CC performance. Three global positioning loggers will be placed on the boom so that we can reference fish tracks to a time-series of position references for the boom. We will run a CFD model for the B2 Forebay under four to six operational scenarios and try to understand the effects of flow on boom position and fish movements.

Based upon route-specific passage estimates from 3D tracking, we will calculate fish passage metrics including Project FPE, FPE by powerhouse, spill efficiency, B1 sluiceway efficiency, B2CC efficiency, combined sluiceway efficiency, B2 FGE, and the effectiveness of the spillway and sluiceways. We will compare these estimates with previous estimates by radio telemetry and hydroacoustics and thoroughly discuss similarities and differences.

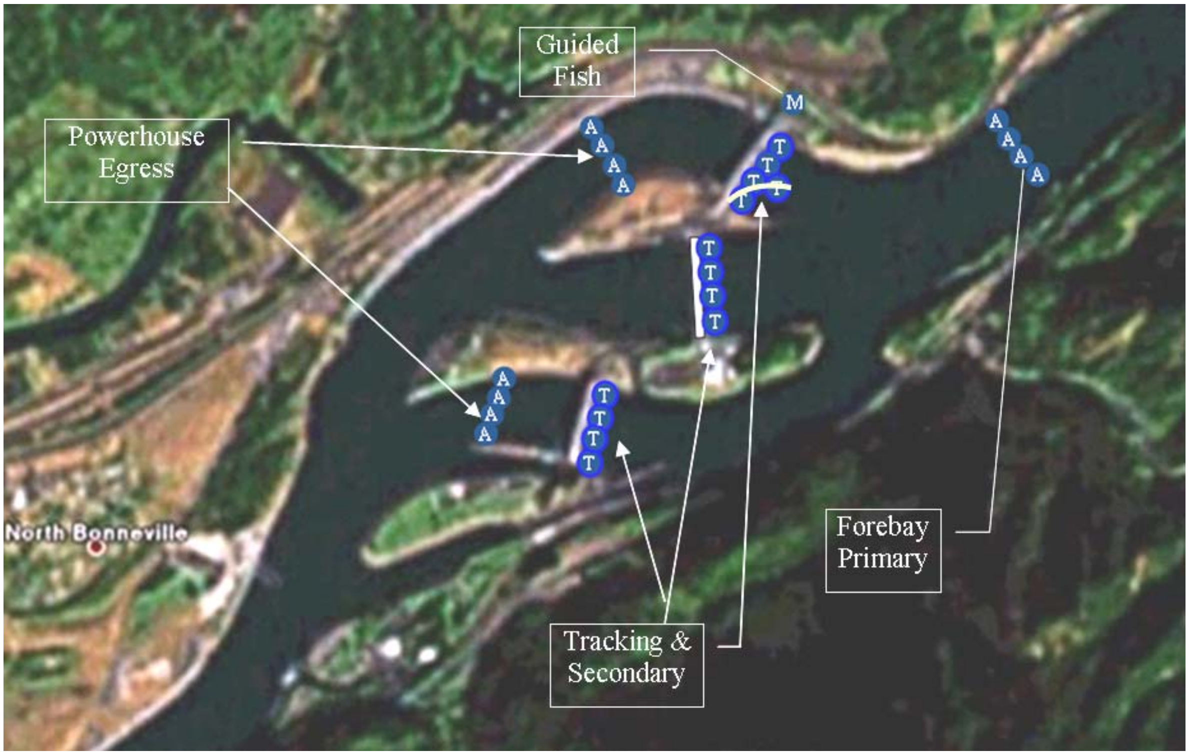

Figure 5. Photograph of Bonneville Dam showing the locations of autonomous nodes (A), 3-D tracking nodes (T), and a mobile node (M) in the JBS at B2. Unlabeled are PIT detectors in the B2CC and the B2 JBS. The yellow line represents a 400 ft long trash boom in the B2 forebay, although the exact location is unknown at this time.

We will deploy a 4-node egress array about 1,000 ft downstream of each powerhouse to confirm passage of tagged fish through B1 and B2 turbines, and to estimate the combined time required for passage and tailrace egress (Figure 5). A hydrophone will be deployed in the B2 bypass channel to detect tagged fish guided by submerged traveling screens (STSs) at B2, and we will query the PTAGIS to confirm passage of tagged fish through the B2CC and the B2 smolt bypass. The distributions of detections within the B1 tailrace array may prove useful for confirming passage of sluiceway assigned fish, if those fish do not disperse north from the southern side of the tailrace where the outfall dumps them. However, there always will be ambiguity when confirming sluiceway passage and passage through turbine units 1 through 5 using the B1 tailrace array. The B2 tailrace array should provide good confirmation of unguided passage through B2 turbines provided detections occur within minutes after fish are tracked into a turbine intake upstream. It is very unlikely that fish passing the spillway, B2CC, or B2 JBS will turn and move back up to be detected on the B1 or B2 tailrace arrays, but the chronology of detections should make obvious such a rare occurrence.

The heart of the survival study is the deployment and maintenance of tailwater detection arrays designated as the primary (Figure 6), secondary (Figure 6), and tertiary (Figure 7). These arrays will be used to detect surviving Chinook salmon assigned a route of passage through Bonneville Dam and to detect surviving control fish released in the Bonneville tailwater by the Estuary Survival Study. In 2007, we will deploy seven nodes in the primary array, five in the secondary, and five in the tertiary, one more than was deployed at each array in 2006. Therefore the number of fish proposed for release in 2007, based upon modeling required sample-sizes using 2006 detection and survival statistics, should be more than adequate to deliver desired precision. We expect array detection probabilities to be even higher in 2007 than they were in 2006. The use of three tailwater survival arrays from 12 to 25 miles below BON will allow us to make two estimates of detection probabilities and survival and to test independence assumptions of the single release model using Burnham Tests 2 and 3 (Burnham et al. 1987).

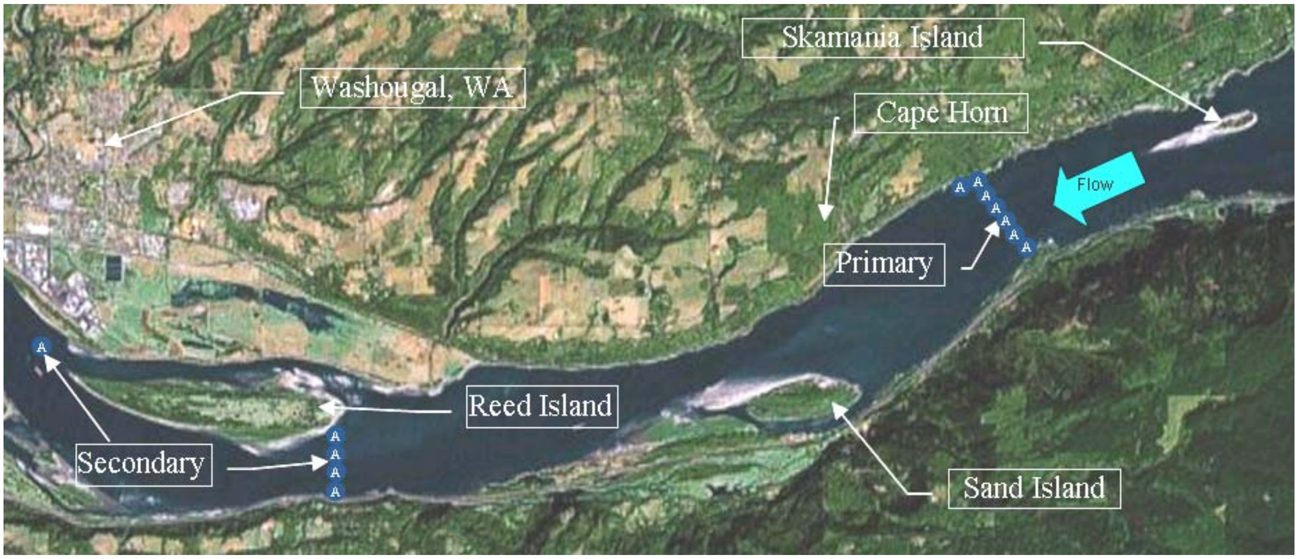

Figure 6. Photograph Showing Locations of Autonomous Nodes in the Primary Tailwater Array between Skamania Island and Sand Island and the Secondary Tailwater Array near Reed Island. The primary array is about 12 miles downstream of Bonneville Dam and the secondary array at Reed Island is about 19 miles downstream of the dam.

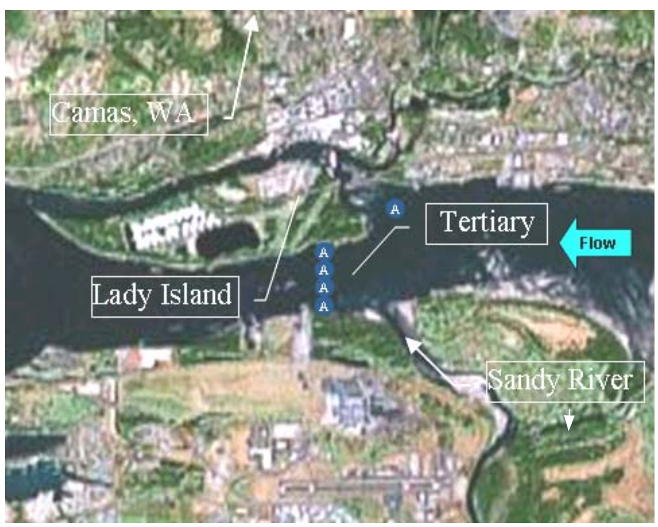

Figure 7. Photograph Showing Autonomous Nodes in the Tertiary Tailwater Array at Lady Island (SM 120), which is about 25 miles below Bonneville Dam.

We will process detection data using TagViz software to match codes detected at least three times in chronological order with released codes, develop detection histories for all tags released below LGR, below TDA, and below BON at each of the detection arrays described above. The software is useful for quickly eliminating improbable false detections based upon detection location and time relative to release times and prior detection locations and times. A web-based version of TagViz can be provided to study sponsors so that they can access detection data, which will be updated within one week after data are downloaded from autonomous nodes. The TagViz data base will contain tag activation and detection histories for all ongoing JSATs studies in 2007, so information about releases and detections for a specific study or all related studies will be readily accessible.

We will estimate forebay egress time by subtracting the time of last detection on 3-D tracking nodes from the time of last detection on the Boat Rock array above the project, and B1 and B2 passage and egress times by subtracting the time of last detection on B1 and B2 tailrace arrays from the time of last detection at a passage route on 3-D tracking nodes in forebay areas.

We will estimate survival by route of passage based upon detection histories of tagged fish at the primary, secondary, and tertiary arrays using paired-release models. The precision of route-specific estimates will depend upon the number of fish passing by each route, so it makes sense to pool estimates by type of route when numbers passing through individual routes are low. We will estimate survival separately for fish released below TDA and fish released below Lower Granite Dam, and if estimates do not differ significantly, we also will provide estimates based on pooled numbers to improve precision of survival estimates. These decisions will be made after all of the data have been acquired and examined. We expect that there will be enough fish to make estimates for the B1 sluiceway, the B2CC, all surface routes combined, B1 turbines, spill bays with 7-ft- and 14-ft-elevation deflectors, the B2 JBS, and B2 turbines. We are unlikely to have enough fish to make useful estimates for individual sluiceway outlets from the B1 forebay, individual turbines or subgroups of turbines at either powerhouse, or individual spill bays. All survival estimates will be accompanied by estimates of precision (one half 95% confidence intervals). We also should be able to look at B1, spillway, and B2 survival by day and night in spring, and by spill-discharge level, which will vary between day and night in summer. We anticipate that spill will be constant 24 hours per day and spring, but will be higher at night than during the day in summer. We will compare all survival estimates to estimates made in previous years with radio telemetry.

After data have been acquired, we will use custom-designed single- and paired-release models (SRM and PRM) to estimate survival for the following reaches:

1. Lower Granite tailwater to the primary forebay array immediately upstream of Boat Rock (SRM)
2. The Dalles tailwater to the primary forebay array (SRM). While estimating survival for this reach was not a specific goal of the study, the configuration of an entrance array to the Project and 3-D tracking nodes will make this estimate possible.
3. The Bonneville forebay primary array to the tailwater primary and secondary arrays (SRM).
4. Bonneville forebay route or types of route to the tailwater primary and secondary arrays (PRM). This will use the ratio of survival estimates of treatment fish passing through a type of route to the survival of control fish released in the tailwater by the Estuary Survival Study.

Often the release-recapture studies are replicated within a season for one or more reasons. One reason is to release tagged smolts throughout the breadth of the migration in order to make inferences to the entire migration season. Another reason is to effectively increase sample size while maintaining individual release sizes that are manageable. In both cases, the performance measure is the average survival estimate across *k* replicates, i.e.

$$\hat{\bar{S}} = \frac{\sum_{i=1}^{k} \hat{S}_i}{k}$$

The variance of which can be expressed as

$$\hat{\text{Var}}\left(\hat{\bar{S}}\right)=\frac{\sigma_s^2+\frac{\sum_{i=1}^{k}Var(\hat{\bar{S}}_i \mid S_i)}{k}}{k},$$

where

σ_s^2 = natural variability in survival S across time,

$Var(\hat{S}_i \mid S_i) =$ measurement error associated with the ith estimate of survival (i.e., $\hat{\bar{S}}_i$)

If natural variability is negligible (i.e., σ_s^2=0, S_1=S_2=…=S), then variance formula above reduces to

$$Var(\hat{\bar{S}})=\frac{Var\left(\hat{S} \mid S\right)}{k}$$

The implication of the last variance formula is that sample size calculations for a replicated investigation can be based on the sample size calculations for a single trial and vice versa. Once an overall release size has been determined (R), the release size per replicate (k) is simply *R/k*. Program SAMPLE SIZE allows the specification of σ_s^2 as either zero or nonzero based on historical evidence.

Among release variances in all reach estimates will be calculated, including the ratio estimates for pair releases. For the ratio of two independent survival rates from a release-recapture study of the form

$$\hat{S}_{\text{Spill bay 1-3 or 15-18}}=\frac{\hat{S}_{\text{Spill bay 1-3 or 15-18}}}{\hat{S}_{\text{Tailrace Control}}}=\frac{\hat{S}_{11}}{\hat{S}_{21}}$$

used to estimate survival at spill bays with 14 ft elevation deflectors, the variance is

$$\begin{aligned}\text{Var}\left(\hat{S}_{\text{Spill bay 1-3 or 15-18}}\right)&=S^2_{\text{Spill bay 1-3 or 15-18}}\left[\frac{\text{Var}\left(\hat{S}_{11}\right)}{S_{11}^2}+\frac{\text{Var}\left(\hat{S}_{21}\right)}{S_{21}^2}\right]\\&=S^2_{\text{Spill bay 1-3 or 15-18}}\left[\text{CV}\left(\hat{S}_{11}\right)^2+\text{CV}\left(\hat{S}_{21}\right)^2\right],\end{aligned}$$

where $\text{CV}=\frac{\sqrt{\hat{\text{V}}\text{ar}(\theta)}}{\theta}$. In other words, the variance of the ratio is a function of the ratio squared times the sum of the CV^2 of the two separate survival estimates.

C.2. VALUE ADDED RESEARCH

In isolation, the proposed study has a simple single release design, but when coupled with other JSATs releases and detection gates, it can deliver more at reduced cost by detecting fish released upstream in the Tag Effects Study. Fish released below Bonneville Dam in the Estuary Study will serve as control releases for this study which will save on tags and labor to implant and release fish. Fish released for this study also will increase the precision of detection and survival estimates for the Estuary Survival Study.

C.3. LIMITATIONS/EXPECTED DIFFICULTIES

Programming 3-D tracking algorithms and display utilities to allow us to animate forebay tracks and facilitate assignment of routes of passage are challenges that will require a significant time investment, but we expect nothing insurmountable in that effort. Those programs and utilities should make future studies much more cost efficient.

C.4. EXPECTED RESULTS AND APPLICABILITY

We expect to accurately assign the route of passage for >95% of juvenile salmon arriving at Bonneville Dam and achieve >80% detection probabilities on downstream survival arrays. Results should provide additional route of passage information and associated metrics on the Bonneville Project. It also will provide juvenile Chinook salmon survival statistics for major dam structures, the B1 sluiceway, two types of spill bays based upon deflectors installed downstream, the B2CC, and B2 turbines. We expect a definitive evaluation of the effect of the 400-ft long trash boom in the B2 forebay based upon forebay guidance metrics and the efficiency and effectiveness of the B2CC relative to its performance in 2004 and 2005 before the trash boom was deployed.

In conjunction with other JSATs survival studies, this study will advance the development of a system-wide survival method, so that juveniles could be tagged and released at Lower Granite Dam and points downstream so estimate of survival can be made for all reaches of the lower Snake and Columbia rivers. The JSATs tags have a longer active battery life than other tags, despite having a high source level and small size. On average, a 10 s JSATS tag can last about 60 days, a 7 s tag about 45 days, and a 5 s tag about 30 days. They also have an inactive shelf life of 1 year with only a 10-15% reduction in battery life once activated.

C.5. SCHEDULE

Spring data collection will occur between May 9 and June 18, 2007 (central 80% of run – Figure 8)
Summer data collection will occur between about June 19 and July 24, 2007 (central 80% of run – Figure 8). The July 24th cutoff should avoid potential water temperature problems biasing fish survival.
A table of preliminary spring results will be completed by July 30, 2007.
A table of preliminary summer results will be completed by September 30, 2007.
A Draft Final Report will be completed by December 31, 2007.
The Final Report will be completed within 60 days after receipt of all pertinent comments.

We are aware that the study design will be reviewed by various State and Federal agencies, and is subject to the approval of the NOAA Fisheries, under the Endangered Species Act. We understand that this means that the study design may be modified prior to the start date, and we will be flexible.

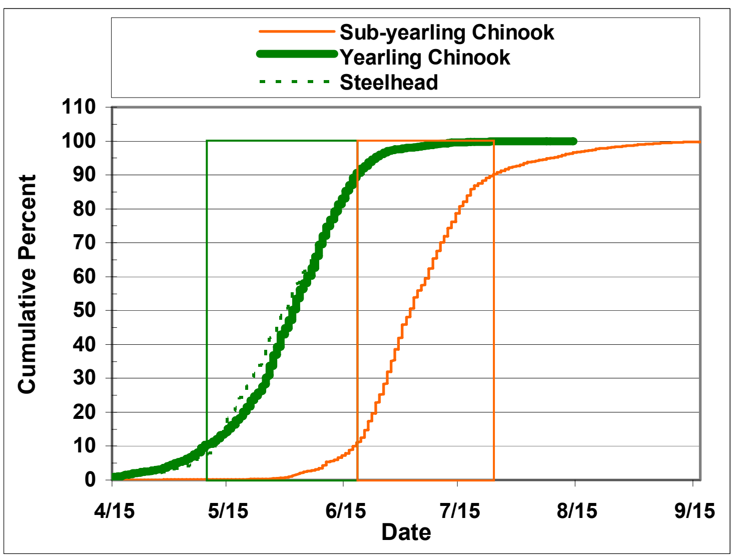

Figure 8. Cumulative Frequency of Numbers of Juvenile Salmonids Passing John Day Dam Based Upon Data from 1996 through 2006 from the Fish Passage Center Web Site.

D. FACILITIES AND EQUIPMENT

About 9,000 JSATs tags and components for 20 3-D tracking nodes will need to be purchased for this study. Forty two autonomous nodes are available. The study will definitely benefit (without cost) from 3,500 YC and 7,000 SYC salmon that will be released at Lower Granite Dam under a tag-effects study, and from 2,000 YC and 3,000 SYC salmon that will be released below Bonneville Dam under an estuary survival study. Fish from the former study potentially could increase sample sizes for this study and fish from the latter study will serve as control fish for this study. All equipment required for surgical tagging, release, and holding of fish is available except for expendable supplies.

E. IMPACTS

Fish will be obtained from the JDA Juvenile Fish Facility. Some small percentage of those fish (about 1%) will die from handling and tagging, but those fish will be used to verify that the primary forebay array does not detect dead fish. During all tests, every effort will be made to minimize the effects of handling and tagging operations. All necessary permits will be obtained from state and federal agencies for the use of tags with ESA listed species, and the study will follow internal PNNL guidelines for the care and treatment of vertebrate animals. The acoustic frequencies transmitted in this study are above those that can be detected by or injure salmon. Autonomous nodes are designed without sharp edges and rigging so they are unlikely to injure fish.

We plan to coordinate closely with the Estuary Survival and the Tag Effects studies to ensure that JSATS nodes are sampling continuously when the 3,500 Snake River YC salmon and 7,000 SYC salmon are passing the Bonneville Project and its survival gates. We also will coordinate with other researchers to avoid conflicts.

F. COLLABORATIVE ARRANGEMENTS AND/OR SUB-CONTRACTS

This is a joint proposal by the PNNL and the NOAA Fisheries. The PNNL plans to subcontract with Dr. John Skalski, School of Aquatic and Fisheries Sciences, University of Washington, to develop survival models and provide statistical oversight.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Gene R. Ploskey (PNNL)	Senior Scientist and Co-Leader - all aspects
Mark Weiland (PNNL)	Senior Scientist and Co-Leader - all aspects
Lynn McComas	Research Fishery Biologist & Co-Leader - Advice and Estuary Survival Coordination
James Hughes (PNNL)	Setup, training, tagging and release, and all other aspects
Shon Zimmerman (PNNL)	Surveying, training, tagging and release, and all other aspects
Kyle Bouchard (PNNL)	Setup, node maintenance and related record keeping, and other as needed
Eric Fischer (PSMFC)	Setup, tagging, node maintenance, data download, and other as needed
Jina Kim (PSMFC)	Tagging coordination and tagging data management, and other as needed
Jessica Vucelick (PNNL)	Tagging and Detection Database Management
John Skalski (UW)	Develop survival models and provide statistical oversight

V. TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred in the form of written and oral research reports. A presentation will be made at the Corps' annual Anadromous Fish Evaluation Program Review. Technology transfer activities may also include presentation of research results at regional or national fisheries symposia, or publication of results in a scientific journal.

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VII. BUDGET

A detailed budget will be provided under a separate cover.